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PHYSICS.—*The size and shape of the electron.* ARTHUR H. COMPTON, Research Laboratory, Westinghouse Lamp Company. (Communicated by G. K. Burgess.)

The radius of the electron is usually deduced from the energy of the electron in motion, assuming its magnetic energy to be identical with its kinetic energy. If the electron is a sphere, its radius must be, according to this assumption, about 1×10^{-13} cm. It is thus sufficiently small to act as a point charge of electricity even with the shortest γ-rays.

Calculating on the basis of such an electron, J. J. Thomson[1] has shown that the fraction of the energy of an electromagnetic wave incident upon an electron which is scattered by it is given by the expression

$$\frac{8\pi}{3}\frac{e^4}{m^2C^4}.$$

This corresponds to a mass absorption coefficient due to a scattering of the primary beam equal to

$$\frac{\sigma}{\rho} = \frac{8\pi}{3}\frac{e^4N}{m^2C^4}, \qquad (1)$$

where N is the number of electrons which contribute to the scattering in a gram of the absorbing medium, C is the velocity of light, and e and m have their usual significance. As Barkla has pointed out, there may be absorption due to other causes,

[1] THOMSON, J. J. Conduction of Electricity through Gases, 2d ed., p. 321.

such as the production of secondary photoelectrons or beta rays, and for other than waves of short length the rays scattered by the different electrons in an atom are nearly enough in the same phase to produce the phenomenon of "excess scattering," so that the absorption coefficient is in most cases considerably greater than the value given by this expression. If the electron acts as a point charge there is, however, no possible grouping of the electrons which can, according to classical theory, produce a smaller absorption than that calculated according to Thomson's formula.

Barkla and Dunlop[2] have shown that for a considerable range of wave-lengths of X-rays the mass scattering coefficients of the lighter elements are given accurately by equation (1) if the number of electrons in the atom is taken to be approximately half the atomic weight. For elements of high atomic weight the phenomenon of excess scattering occurs, except with the very shortest wave-lengths, and the absorption coefficient due to scattering becomes much greater than this value. For wave-lengths less than 2×10^{-9} cm., however, the absorption coefficient becomes very appreciably less than that theoretically calculated, falling as low as one-fifth as great for the shortest γ-rays. Soddy and Russell[3] and Ishino[4] have shown that for these shortest rays the amount of energy scattered by the different elements is accurately proportional to their atomic numbers, so that all the electrons outside the nucleus are effective in producing absorption. It is therefore impossible to account for this very considerable decrease in the absorption coefficient for very short electromagnetic waves if the electron is considered to be a point charge of electricity.

If, however, the diameter of the electron is comparable in magnitude with the wave-length of the incident wave, the radiation scattered by different parts of the electron will be so different in phase that the energy of the scattered rays will be materially reduced. If, for example, the charge on an electron

[2] Barkla and Dunlop. Phil. Mag., March, 1916.
[3] Soddy and Russell. Phil. Mag. **18**: 620. 1910; **19**: 725. 1910.
[4] Ishino. Phil. Mag. **33**: 129. 1917.

is supposed to be in the form of rigid spherical shell, incapable of rotation, a simple calculation shows that the mass absorption coefficient due to scattering is given by

$$\frac{\sigma}{\rho} = \frac{8\pi}{3}\frac{e^4N}{m^2C^4}\sin^4\left(\frac{2\pi a}{\lambda}\right)\Big/\left(\frac{2\pi a}{\lambda}\right)^4, \qquad (2)$$

where a is the radius of the spherical shell and λ is the wavelength of the incident beam. For long waves this becomes identical with equation (1), but it decreases rapidly as the wavelength approaches the diameter of the electron, as is shown in curve I, figure 1. Such an assumption is therefore able to explain at least qualitatively the decrease in the absorption for electromagnetic waves of very high frequency.

It would appear more reasonable to imagine the spherical shell electron to be subject to rotational as well as translational displacements when traversed by a γ-ray. The scattering due to such an electron is difficult to calculate, but an approximate expression can be obtained if the electron is considered to be perfectly flexible, so that each part of it can be moved independently of the other parts. On this hypothesis it can be shown that the intensity of the beam scattered by an electron at an angle θ with an unpolarized beam of γ-rays is given by the expression

$$I_\theta = I\frac{e^4(1+\cos^2\theta)}{2r^2m^2C^4}\left\{\left(\frac{\lambda}{4\pi a}\right)^2\sin^2\left(\frac{4\pi a}{\lambda}\sin\frac{\theta}{2}\right)\Big/\sin^2\frac{\theta}{2}\right\}. \qquad (3)$$

Here I is the intensity of the incident beam, r is the distance at which the intensity of the scattered beam is measured, and the other quantities have the same meaning as before. The mass absorption coefficient due to scattering by such an electron is therefore

$$\frac{\sigma}{\rho} = 2\pi Nr^2\int^\pi \frac{I_\theta}{I}\sin\theta\, d\theta. \qquad (4)$$

This integral may be evaluated graphically or by expansion into a series. The values of σ/ρ in the case of aluminium, taking the numbers of electrons per atom to be 13, are plotted in curve II, figure 1, for different values of a/λ. The values for a

rigid spherical electron which is subject to rotation should lie between curves I and II for the range of a/λ here plotted.

Unfortunately the experimental data are too meager to submit these formulae to accurate quantitative test. There are,

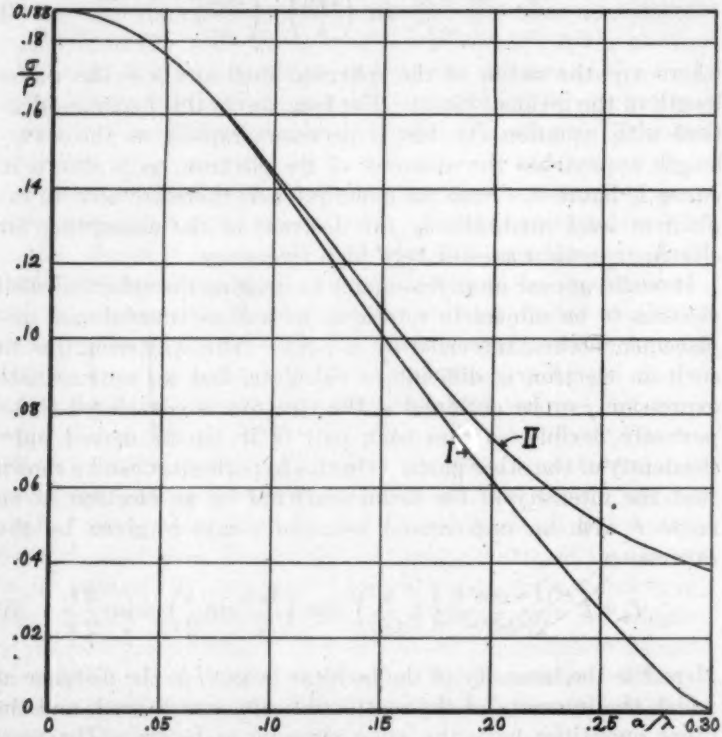

Fig. 1. Mass absorption coefficient for electrons (I) in the form of rigid spherical shells incapable of rotation, and (II) in the form of perfectly flexible spherical shells. The number of electrons per atom is taken as 13.

however, three points on the curve which are established with some accuracy. Barkla[5] has found that for relatively long X-rays the light elements scatter accurately according to equation (1), so that the part of the curves where a/λ is small is verified.

[5] BARKLA and DUNLOP. Phil. Mag.

Hull and Rice[6] have shown that for wave-lengths in the neighborhood of 0.17×10^{-8} cm. the value of σ/ρ for aluminium is about 0.12. From curve I this corresponds to an electronic radius of 2.2×10^{-10} cm., while curve II gives 2.3×10^{-10} cm. Ishino[7] finds that the value of σ/ρ, using the hard γ-rays from radium-C, is about 0.045. Taking the effective wave-length to be[8] 0.093×10^{-8} cm., curve I gives $a = 2.1 \times 10^{-10}$ and curve II gives $a = 2.5 \times 10^{-10}$ cm. Using either formula the agreement between the two values of the radius is within the limits of probable experimental error. The unusually low absorption coefficient for γ-rays can therefore be quantitatively explained on the hypothesis that the electron is a spherical shell of electricity of radius about 2.3×10^{-10} cm.

Another difficulty that is found in J. J. Thomson's simple theory is that it predicts that if a beam of X-rays is passed through a thin plate the intensity of the scattered rays on the two sides of the plate should be the same. It is well known, however, that the scattered radiation on the emergent side of the plate is much more intense than that on the incident side, both in the case of relatively soft X-rays and in the case of hard γ-rays. Barkla and Ayres[9] have shown that for rather hard X-rays and for those substances of low atomic weight whose absorption coefficient can be calculated accurately by equation (1) this prediction of Thomson's theory is also valid. In the case of the heavier atoms and the longer waves, however, the rays scattered at a small angle with the incident beam by the different electrons in the atom are so nearly in the same phase that the intensity is considerably increased, while at large angles the phase difference is much greater, and the intensity is much smaller. This explanation cannot, however, be applied to the excess scattering of γ-rays of short wave-length, since experiment shows[10] that for longer waves the light elements show no

[6] Hull and Rice. Phys. Rev. **8**: 326. 1916.
[7] Ishino. Phil. Mag. **33**: 129. 1917.
[8] Rutherford and Andrade. Phil. Mag. **28**: 263. 1914.
[9] Barkla and Ayers. Phil. Mag. **21**: 271. 1911.
[10] Barkla and Ayers. Phil. Mag. **21**: 271. 1911.

excess scattering on the emergent side, indicating that the electrons act independently, while for hard γ-rays the excess scattering is the same as for the heavier elements.

The same difficulty is present if instead of considering the electron as a point charge it is assumed to be a rigid spherical shell incapable of rotation, as this assumption also makes the scattered radiation symmetrical on the incident and the emergent sides. If, however, the electron is a spherical shell of electricity which can be rotated by a passing electromagnetic wave, it is

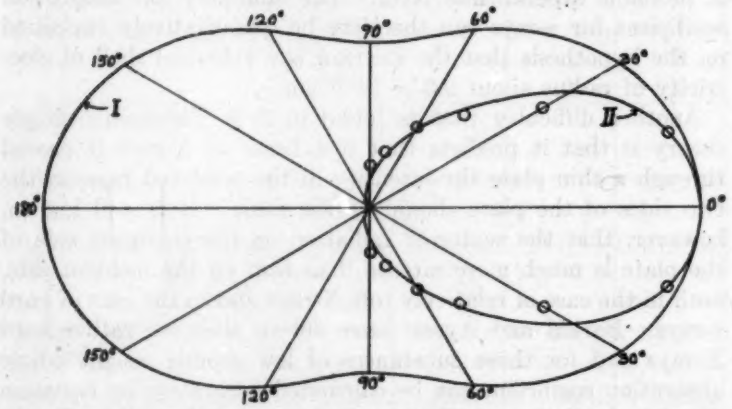

Fig. 2. The intensity of the radiation scattered at an angle θ with the incident radiation, the electron being a perfectly flexible spherical shell. I, radius of electron = 0; II, radius = $3\pi\lambda/4$.

capable of producing excess scattering on the emergent side for short γ-rays in much the same manner as groups of electrons in the atom produce excess scattering in the case of the longer X-rays. For purposes of calculation it is again simpler to consider the nearly equivalent case of the electron which is a flexible spherical shell. The intensity at any angle is then given by equation (3). When $a = 0$, this expression becomes identical with that calculated on Thomson's theory, and the corresponding values are plotted in curve I of figure 2. In curve II, I_θ/I is plotted for different values of θ, using the value $a = 3\pi\lambda/4$.

The circles are experimental values determined by D. C. H. Florance[11] using the γ-rays from radium bromide scattered by a plate of iron. Inasmuch as these rays are heterogeneous, and as the softer rays are scattered relatively more strongly at larger angles, the agreement of the experimental values with curve II is as good as can be expected.

A better quantitative test of this explanation is afforded by Ishino's observation[12] that the radiation scattered on the incident side of a plate struck by hard γ-rays from radium-C is about 15 per cent of that scattered on the emergent side. On the hypothesis of the electron as a flexible sphere this ratio is given by the relation

$$\frac{I_i}{I_e} = \int_{\pi/2}^{\pi} I_\theta \sin\theta\, d\theta \Big/ \int_0^{\pi/2} I_\theta \sin\theta\, d\theta \qquad (5)$$

The values of this ratio for different values of a/λ are plotted in figure 3. This curve explains beautifully the observation of Florance that the "incident" scattered rays are softer than the "emergent" and the primary rays, since it shows that the relative amount of the rays scattered backward is much greater for soft, or long wave-length, γ-rays than for hard rays. Rutherford and Andrade[13] have found the hard γ-rays from radium-C to consist of a strong line, $\lambda = 0.099 \times 10^{-8}$, and a weaker line, $\lambda = 0.071 \times 10^{-8}$ cm. Taking into account this selective effect, we may take the effective wave-length to be 0.095×10^{-8} cm. On this basis, and using $a = 2.3 \times 10^{-10}$ as determined above, the calculated value of the ratio of the incident to the emergent scattered radiation is 8 per cent. The agreement is hardly within the probable experimental error, but the calculated value is at least of the proper order of magnitude, which is a strong verification of a flexible or a rotatable electron.

According to electromagnetic theory it is obvious that the mass of an electron cannot be accounted for on the basis of a uniform distribution of electricity over the surface of a sphere

[11] FLORANCE. Phil. Mag. **20**: 921. 1910.
[12] ISHINO. Phil. Mag. **33**: 129. 1917.
[13] RUTHERFORD and ANDRADE. Phil. Mag. **28**: 263. 1914.

of the size here assumed. Much the same effect, so far as the scattering of γ-rays is concerned, results from the conception of the electron as a ring of electricity of diameter comparable with the wave-length of the incident beam. It has been shown by

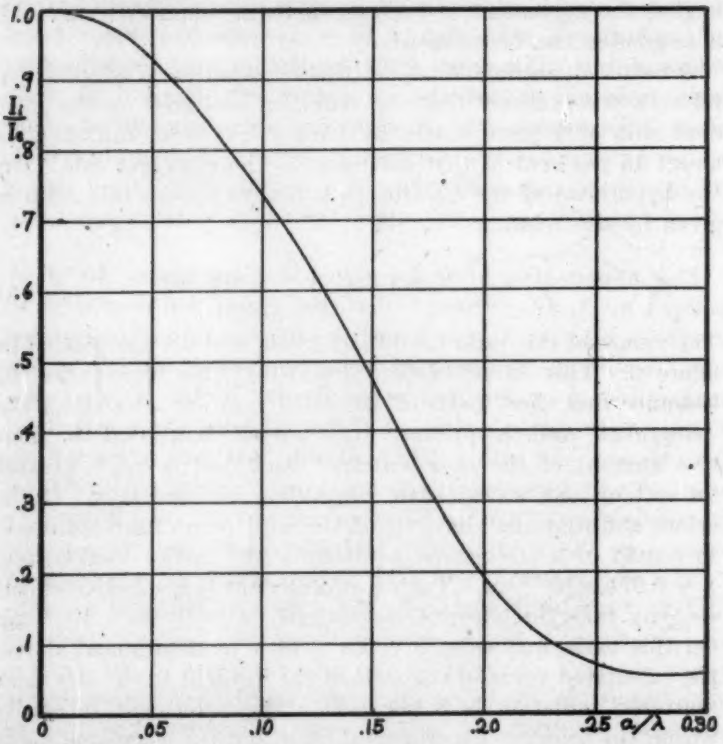

Fig. 3. Ratio of the intensity of the radiation scattered on the incident side to that of the radiation scattered on the emergent side of a plate. The electron is assumed to be a flexible sphere.

Davisson[14] and Webster[15] that this conception is compatible with the electromagnetic theory of the mass of the electron. I have not as yet been able to solve completely the problem of the scattering produced by such ring electrons. Approximate

[14] Davisson. Phys. Rev. 9: 570. 1917.
[15] Webster. Phys. Rev. 9: 484. 1917.

methods show, however, that if the electron is a rigid ring whose plane is invariable, the scattered energy follows equation (2) rather closely, and is symmetrical on the incident and the emergent sides. If the electron is a flexible ring, or one capable of rotation about any axis, the scattering is more nearly that given by equation (4), but should be somewhat greater for large values of a/λ. The ratio of the incident to the emergent scattered radiation should also be appreciably larger than that given by expression (5). It seems probable, therefore, that the scattering of γ-rays and X-rays may be completely explained on the hypothesis that the electron is a ring of electricity of radius about 2×10^{-10} cm., if the ring is capable of rotation about any axis.

This hypothesis makes it possible to explain also the effect noticed by A. H. Forman[16] that the absorption coefficient of iron for a beam of X-rays is greater when the iron is magnetized parallel with the transmitted beam than when the iron is unmagnetized or magnetized perpendicular to the X-ray beam. Using an effective potential of 27,000 volts the effect was about 0.4 per cent, and with a potential of 81,000 volts it was 0.6 per cent. From X-ray spectra obtained under similar circumstances it can be shown that the effective wave-length used in the two cases was about 1.0×10^{-8} and 0.5×10^{-8} cm. respectively. If the ring electron acts as a tiny magnet, as suggested by Parson,[17] it may be turned by the magnetic field until its plane is perpendicular to the incident beam of X-rays This will make the rays scattered by the different parts of the electron more nearly in the same phase, so that the absorption due to scattered radiation will be increased. Moreover, since the incident rays can get a better hold on the electron in this position, its displacement will be greater than when unorientated, and absorption due to transformation of the X-rays into other types of energy will be greater. For the relatively long waves used by Forman the ratio of the absorption coefficient when

[16] FORMAN. Phys. Rev. 7: 119. 1916.

[17] PARSON, A. L. Smithsonian Misc. Collections, Nov. 1915. Parson estimates his "magneton," or ring electron, to have a radius of 1.5×10^{-9} cm.

magnetized to that when unmagnetized should be approximately

$$k\left(\frac{2\pi a}{\lambda}\right)^2 \Big/ \sin^2\left(\frac{2\pi a}{\lambda}\right)$$

where a is the radius of the ring electron and k is the fraction of the electrons which are oriented by the magnetic field. Using the value $a = 2.3 \times 10^{-10}$ cm., this means that the change in the absorption due to magnetization for $\lambda = 1.0 \times 10^{-8}$ cm. is 0.7 k per cent, and for $\lambda = 0.5 \times 10^{-8}$ cm. is 2.8 k per cent. From the observed values of this difference we find that the fraction of the electrons oriented by the magnetic field is 0.6 and 0.26. The experimental basis of the latter value is much the more certain. Taking the number of electrons in the iron atom to be 26, this means that in order to explain Forman's effect in terms of ring electrons a number $0.26 \times 26 = 7$ of the electrons must be capable of being oriented by the magnetic field. This is what would be expected if it is the 8 valence electrons of iron which are responsible for its ferro-magnetic properties. Our hypothesis of a ring electron of radius 2.3×10^{-10} cm. is therefore capable of explaining satisfactorily Forman's effect.

It should be noted that Forman explains his effect as being due to an orientation of the *molecules* in the iron. The experiments of Rognley and the writer[18] on the effect of magnetizing a crystal on the intensity of the beam of X-rays reflected by it have shown that any orientation of the molecules, if it occurs at all, must be extremely small. It was found further that unless it is very nearly isotropic the atom also is not rotated by magnetization. Thus Forman's explanation of his effect is inadequate. The fact that his experiments can be explained in terms of an orientation of the electrons must be taken as a confirmation of the conclusion arrived at by Rognley and the writer that it is not the atom as a whole, but the electron itself that is the ultimate magnetic particle.

[18] COMPTON and ROGNLEY. Science (N. S.) **46**: 415. 1917.

Summary. Ishino's experiments, showing that the scattering of hard γ-rays by different materials is strictly proportional to the number of electrons and is not proportional to the masses, proves that the electrons are responsible for practically all of the scattering, and that for these wave-lengths they act independently of each other. According to the classical electrodynamical theory, this means that if the electrons are sensibly point charges of electricity, the absorption coefficient due to scattering for these rays must be given by equation (1). Since this equation does not hold for these wave-lengths, we cannot consider the electron to be a point charge. In order to account for the small absorption coefficient of γ-rays *the electron must have an effective radius of about* 2.3×10^{-10} *cm.* In order to explain the fact that the emergent scattered radiation is more intense than the incident radiation, it is necessary to assume further that *the different parts of the charge of the electron can possess certain motions independently of each other.* It appears that these phenomena, together with the electromagnetic mass of the electron, can be quantitatively explained on the hypothesis that the electron consists of a ring of electricity subject to rotation about any axis and of radius about 2.3×10^{-10} cm. This hypothesis is confirmed by the fact that it explains satisfactorily Forman's effect of magnetization of iron upon its absorption coefficient, for which there is no other apparent explanation.

CHEMISTRY.—*A silica-glass mercury still.* J. C. HOSTETTER and R. B. SOSMAN, Geophysical Laboratory.

Although numerous electrically heated mercury stills have been described and are doubtless being used with satisfaction, nevertheless there is one undesirable feature that is common to all vacuum mercury stills and that is avoided in the one about to be described: namely, that a still made of ordinary glass or even of combustion glass will, when slightly overheated, collapse under the pressure of the atmosphere.[1]

[1] The form of failure of such a tube is of some interest in itself. One of our ordinary glass stills that collapsed one night when the voltage on the power line became too high yielded symmetrically around its vertical axis, instead of flattening out, producing a figure with three cusps separated by angles of 120 degrees.

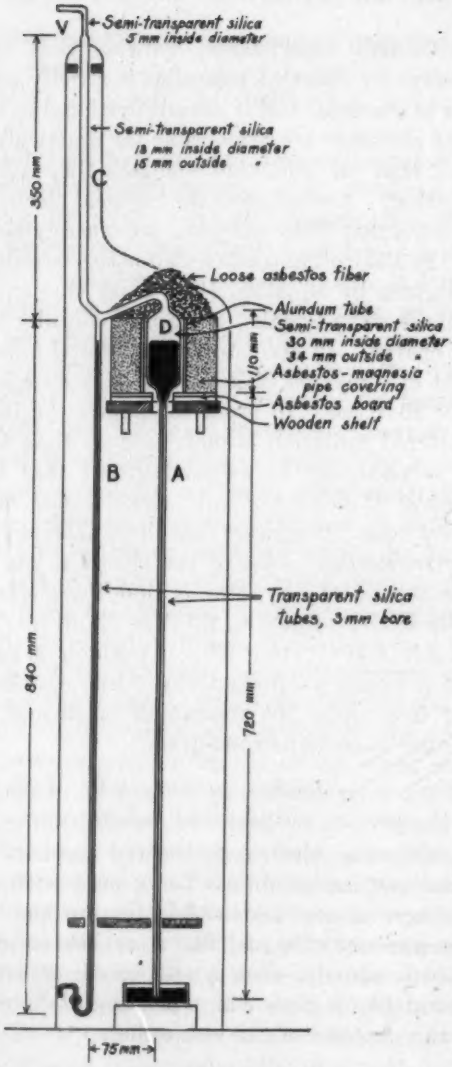

Fig. 1. Silica-glass mercury still

After several such exasperating experiences with glass stills—the overheating being caused by rising voltage on the power line—we had our still remade of silica glass (fused quartz, or "quartz glass"), and it has been in use more or less continuously for several years. The additional cost of the silica-glass still is well expended in the insurance thereby secured against interruption of the distillation. We have been requested to put on record a brief description of the still, having had a number of inquiries for information concerning its design.

Design of the still. The construction is shown in detail in figure 1. An effort has been made to simplify the still as much as possible in order to minimize the difficulties connected with the working of silica glass. No originality is claimed for the design: an inspection of the diagram will show that the essential points of any continuously acting still have been embodied, some having been taken from one still and some from another.

The distillation chamber (*D*) has an inside diameter of 30 mm. and a length of 110 mm. The condenser (*C*) has an inside diameter of 13 mm. Both of these parts of the apparatus are made of the semitransparent inexpensive variety of silica glass. The smaller vertical tubes, *A* and *B*, however, are made of the transparent variety, thus enabling one to observe readily the rate of condensation and to see whether the vacuum is being maintained. At *V* the still is connected to a suction pump that gives a pressure of 1 cm. of mercury or less. This joint is made with hard De Khotinsky cement and is located where it will be air-cooled as thoroughly as possible. The lengths of the small vertical tubes must be such that at ordinary atmospheric pressure the distillation chamber is about half filled: the length of *A* is 720 mm. to the bottom of the distillation chamber, while *B* has a length of 840 mm. The inside diameters of *A* and *B* should not be too small; the tubes on our still have a bore of 3 mm., but 5 mm. might be better.

The furnace. The furnace is wound so as to go directly on the 110-volt circuit (alternating or direct current) without any external resistance. The power consumption is about 60 watts. Since the temperature required is comparatively low, various

designs for the furnace might be safely employed; such, for instance, as winding the resistance wire on an asbestos-covered metal tube. Having at hand, however, an alundum tube of suitable size, we found it convenient to wind the wire directly upon this tube, and to hold the wire in place with alundum cement. The alundum tube has an inside diameter of 1½ inches (38 mm.) and is 4½ inches (114 mm.) long. The winding consists of 51 turns (12 to the inch) of No. 30 nichrome wire (diameter 0.010 inch, or 0.25 mm.), giving a total of approximately 24 feet (7.3 meters) of wire. Its resistance is about 160 ohms cold and 200 ohms hot, and the current is about 0.6 ampere. The furnace rests on a disk of heavy asbestos board and is jacketed with ordinary asbestos-magnesia pipe covering. The neck of the still is covered with loose asbestos fiber.

Preliminary treatment of the mercury. As here constructed this still is intended for the final distillation of mercury that has been previously treated to remove the gross impurities. This may be done (a) by the well-known process of Lothar Meyer[2] since modified by Hildebrand[3] and by Desha,[4] in which the mercury is allowed to pass in a fine stream through a long column of dilute nitric acid; (b) by making the mercury the anode in a nitric acid bath and electrolyzing;[5] (c) by passing air through the slightly heated mercury;[6] (d) most thoroughly of all, by the method of Hulett and Minchin,[7] consisting in subjecting the mercury to a preliminary distillation during which a stream of air is bubbled through it. The first three methods have recently been combined and developed into an automatic process.[8]

Another very simple but surprisingly effective method of removing impurities, which is not generally known and which has been ascribed to Henry Leffman, is to shake up the con-

[2] MEYER, LOTHAR. Z. Anal. Ch. 2: 241. 1863.
[3] HILDEBRAND, J. H. J. Am. Chem. Soc. 31: 933–935. 1909.
[4] DESHA, L. J. Am. Chem. J. 41: 152. 1909.
[5] WOLFF, F. A., and WATERS, C. E. Bull. Bur. Standards 3: 624–625; 4: 9–11. 1907.
[6] CRAFTS, J. M. Bull. Soc. Chim. Paris 49: 856. 1888.
[7] HULETT, G. A., and MINCHIN, H. D. Phys. Rev. 21: 388–398. 1905.
[8] PATTEN, H. E., and MAINS, G. H. J. Ind. Eng. Chem. 9: 600–603. 1917.

taminated mercury with cane sugar. After such a treatment and a filtration through a pin hole the mercury comes out remarkably clean.

Unless the mercury has been partially purified in some manner the tube *A* may become clogged by the accumulation of foreign metals which concentrate in the tube as the mercury distils.

If a wet process of purification has been employed, it is best to dry the mercury by bubbling air through it for several hours before introducing it into the still.

After a distillation from this apparatus the mercury should be given a filtration through a pin hole in a filter paper in order to remove a slight film of oxide produced by the oxidation of metal impurities by the small amount of air remaining in the still. After such a distillation and filtration the mercury may be safely used in vacuum gages and in thermoregulators, and for other purposes requiring a reasonably pure product.

The yield of distilled mercury is about 400 cc. per twenty-four-hour day, when the still is operated with a vacuum of approximately 1 cm. of mercury.

PHYSIOLOGY.—*Sensory fibers in the mesencephalic root of man and the guinea pig.* WILLIAM F. ALLEN, Department of Anatomy, University of Oregon Medical School, Portland, Oregon.

As a result of Marchi stained serial sections of the brain stems of a five year old girl and two guinea pigs, in which the left V-roots of the guinea pigs were previously severed behind the semilunar ganglion and the V-sensory root of the girl had been destroyed by a large glioma in the pons region, the following preliminary statement can be made: A number of sensory fibers arising from cells in the semilunar ganglion follow the ventral surface of the sensory root of the trigeminal nerve into the brain stem to pass dorsally between the V-motor and the V-sensory (substantia gelatinosa) nuclei to end in considerable numbers in the motor nucleus. Other fibers continue dorsad and cephalad in the V-mesencephalic root to terminate in the

locus coeruleus. Degenerated fibers were fairly abundant in the mesencephalic root as far cephalad as the point of crossing of the IV-nerve root. A few of these sensory fibers apparently continue farther cephalad in the mesencephalic root to end in the V-mesencephalic root nucleus lateral to the central gray mass above the IV and III nuclei. Additional experiments are in progress to determine the distribution of the nerve fibers arising from the V-mesencephalic nucleus and the locus coeruleus.

CONCHOLOGY.—*The land mollusks of the genus Obba from the islands of Bohol and Panglao, P. I.*[1] PAUL BARTSCH, U. S. National Museum.

The United States National Museum has recently received a lot of shells belonging to the genus *Obba*, collected by Gilbert S. Perez on the islands of Bohol and Panglao, which made a revision of the group necessary. This has resulted in the recognition of a number of new forms, brief critical diagnosis of which are presented herewith. A fuller account and figures of these will be published in a monograph on the Philippine members of the genus, which is in preparation.

Obba rota Perezi, n. subsp.

The present race differs from *Obba rota rota* Broderip, which is at home on the island of Siquijor, in being decidedly more elevated and in having the peripheral keel less upturned at the edge, and situated about half way between the base and summit, while in *Obba rota rota* it is at the anterior extremity of the upper third.

The type, Cat. No. 216983, U. S. N. M., comes from Bilar, Bohol, and measures: altitude, 10.2 mm.; greater diameter, 27.6 mm.; lesser diameter, 22 m.

Obba rota panglaoensis, n. subsp.

This race is much smaller and darker than *Obba rota rota* Broderip. It is elevated like *Obba rota perezi* B. and has the keel similarly situated, but the sculpture is rougher in the present race.

The type, Cat. No. 216984, U. S. N. M., comes from Panglao Panglao Island, and measures: altitude, 9.7 mm.; greater diameter, 23.5 mm.; lesser diameter, 18.7 mm.

[1] Published by permission of the Secretary of the Smithsonian Institution.

Obba moricandi hernandezensis, n. subsp.

The present race is more elevated and narrower than typical *Obba moricandi moricandi* Sowerby which comes from Jacna, Bohol. The pronounced characteristic color bands of the spire in the typical form are completely absent and only a faint narrow light-brown thread encircles the base. Our specimens come from Garcia Hernandez, Bohol.

The type, Cat. No. 216980, U. S. N. M., measures: altitude, 19.3 mm.; greater diameter, 33.2 mm.; lesser diameter, 25.2 mm.

Obba scrobiculata valenciensis, n. subsp.

The rought axial sculpture, characteristic of *Obba scrobiculata scrobiculata* Pfeiffer, is reduced to a minimum, while the color bands on the upper surface of the typical form are merely indicated by obsolete lines in the present race. The upper surface is marked by broad, light and dark oblique axial zones, which lend it a watered-silk effect. A color band is present on the base.

The type, Cat. No. 216986, U. S. N. M., comes from Valencia, Bohol, and measures: altitude, 13 mm.; greater diameter, 29.3 mm.; lesser diameter, 23 mm.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this JOURNAL and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Notes on the geology and iron ores of the Cuyuna district, Minnesota.* E. C. HARDER and A. W. JOHNSTON. U. S. Geological Survey Bulletin 660–A. Pp. 26, with maps, sections, and illustrations. 1917.

The Cuyuna iron-ore district is near the geographic center of Minnesota, about 90 miles west of Duluth and 55 miles southwest of the western part of the Mesabi district. In contrast with some of the other Lake Superior iron-ore districts, it is without marked topographic relief. It is mainly a region of low, irregular morainic hills interspersed with lakes and extensive swamps and marshes.

The productive part of the Cuyuna district is commonly divided into two ranges—the north range, including the part lying north of the Northern Pacific Railway, and the south range, including the belt lying south of the railway. The discovery of iron ore in the Cuyuna district was entirely due to the existence of abnormal magnetic attractions in the region.

The bedrock in the district and adjacent region is largely concealed by a mantle of glacial drift that varies in thickness from 15 feet to about 400 feet. No rock exposures are known in Crow Wing County, in which most of the district is situated. The rocks that have been found up to the present time in the district can all be grouped under three classes: (1) sedimentary and igneous metamorphosed rocks interlayered with each other in beds and lenses and usually having steep dips due to extensive folding, (2) igneous rocks intruded into the metamorphosed rocks subsequent to their metamorphism and deformation, and (3) younger rocks which lie horizontally on the eroded surfaces of the rocks of the other two classes. The age of the various rocks is not definitely known.

The iron-bearing formation of the Cuyuna district presents a variety of lithologic types. Among the more common rocks composing it are hematitic and limonitic chert and slate, cherty and slaty iron carbonate, siliceous magnetitic slate, amphibole-magnetite rock, jaspilite, dark-blue, red, brown, black, and yellow iron ore, black, red, and brown manganiferous iron ore, green chloritic schist, and dark-red hematitic schist.

It is generally supposed that the original rock from which the present hematitic and limonitic chert and iron ore have in large part been formed is a banded cherty iron-carbonate rock.

The ore bodies are as a rule roughly tabular in shape, with the longer axes parallel to the bedding of the inclosing rocks. As the beds of rock generally dip steeply, the ore bodies are shown at the surface as bands that extend for considerable distances along the strike of the beds. They range in width to several hundred feet and are usually very long, some of the known ore bodies being more than a mile in length. The Cuyuna ore shows all stages of hydration from pure reddish-blue hematite to ocherous yellow limonite, and both argillaceous and siliceous phases are common. R. W. STONE.

PARASITOLOGY.—*A further note on the life history of* Gongylonema scutatum. B. H. RANSOM and M. C. HALL. Journ. Parasit. **3**: 177–181. June, 1917.

Seurat in recent publications has questioned certain conclusions reached by the writers in former papers relative to the life history of the nematode *Gongylonema scutatum*. In the present paper these conclusions are upheld, namely that dung beetles and croton bugs fed upon the eggs of *G. scutatum* become infested with an encysted larval stage of the parasite and that it is quite evident that sheep, cattle, and other suitable mammalian hosts become in turn infested as a result of swallowing infested insects (under natural conditions various species of dung beetles). Certain larval nematodes found by Seurat (1916) in several species of *Blaps* in Algeria are not *G. scutatum* and it is not improbable that those which he found in various Algerian beetles and identified as the larvae of *G. mucronatum* Seurat in reality belong to the species *G. scutatum*. B. H. R.

MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

The 113th meeting of the Academy, the nineteenth annual meeting, was held at the Cosmos Club at 8.30 p.m., Thursday, January 11, 1917. In the absence of the Recording Secretary, the chair appointed F. E. WRIGHT acting secretary. The minutes of the last annual meeting were read and approved.

The reports of the Corresponding Secretary, the Recording Secretary, the Treasurer, and the Auditing Committee were read and accepted. WILLIAM R. MAXON presented the report of the editors, which was accepted.

The tellers reported that the mail ballot had resulted in the election of the following officers for the year 1917:

President: W. H. HOLMES.
Non-resident Vice-Presidents: E. W. MORLEY and W. S. THAYER.
Corresponding Secretary: F. E. WRIGHT.
Recording Secretary: WILLIAM R. MAXON.
Treasurer: WILLIAM BOWIE.
Managers, Class of 1920: PAUL BARTSCH, C. S. SCOFIELD.

Nominations for Vice-presidents from the affiliated societies were then presented, and the following Vice-Presidents were elected:

Anthropological: WALTER HOUGH.
Archæological: MITCHELL CARROLL.
Biological: W. P. HAY.
Botanical: A. S. HITCHCOCK.
Chemical C. S. HUDSON.
Electrical Engineers: R. H. DALGLEISH.
Engineers: A. L. BALDWIN.
Entomological: W. D. HUNTER.
Foresters: GEORGE B. SUDWORTH.
Geographic: O. H. TITTMANN.
Geological: A. C. SPENCER.
Historical: ALLEN C. CLARK.
Medical: G. WYTHE COOK.
Philosophical: E. BUCKINGHAM.

The meeting was then adjourned for five minutes, after which the Academy met in joint meeting with the Chemical Society, with C. L. ALSBERG in the chair. R. B. SOSMAN presented his address as retiring president of the Chemical Society, on the subject: *Some problems of the oxides of iron.* The address has been published in the Journal of the Academy (7: 55–72. 1917).

R. B. SOSMAN, *Corresponding Secretary.*

The 114th meeting of the Washington Academy of Sciences was held in the auditorium of the Natural History Building of the National Museum the evening of February 1, 1917. The retiring president of the Academy, Dr. L. O. HOWARD, delivered an illustrated lecture entitled *The carriage of disease by insects.* The address has since been published in abridged form in the Journal of the Academy (7: 217–222. April 19, 1917).

The 115th meeting of the Academy was held in the Assembly Hall of the Cosmos Club the evening of March 15, 1917, the occasion being the presentation of the first of a series of public lectures on Heredity. Prof. H. S. JENNINGS, Johns Hopkins University, Baltimore, delivered an address entitled *Observed changes in hereditary characters in relation to evolution.* This has since been published in full in the Journal of the Academy (7: 281–301. May 19, 1917).

The 116th meeting of the Academy was held in the Assembly Hall of the Cosmos Club the evening of March 29, 1917, the speaker being Dr. OSCAR RIDDLE, of the Department of Experimental Evolution, Cold Spring Harbor, New York. Doctor Riddle's lecture, entitled *The control of the sex ratio,* has been published in full in the Journal of the Academy (7: 319–356. June 4, 1917).

The 117th meeting of the Academy was held in the Assembly Hall of the Cosmos Club the evening of April 13, 1917. The speaker, Prof. W. E. CASTLE, of Harvard University, delivered an address entitled *The rôle of selection in heredity.* This lecture, which concluded the series on Heredity, has since been published under a slightly different title in the Journal of the Academy (7: 369–387. June 19, 1917).

WILLIAM R. MAXON, *Recording Secretary.*

ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 513th meeting of the Society was held at the National Museum, October 2, 1917, at 4.30 p.m.

Dr. ALEŠ HRDLIČKA, Curator of Physical Anthropology, U. S. National Museum, addressed the Society on *Bohemia and the Bohemians,* illustrating his address with lantern slides.

"Bohemia," said Dr. Hrdlička, "is not a large country but one with a great history; and while among the oldest in Europe and one of the most battered by fate it is struggling vigorously to regain its freedom which it lost in the dark period of the seventeenth century. Its people have been endowed with an unquenchable love of liberty and its free sons are now fighting in every Allied army."

The speaker then noted the geographic position of Bohemia in the center of Europe, surrounded by a natural boundary of hills and mountains. Its area is about one-fourth greater than that of Switzerland,

with a density of population nearly twice as great as that of France, and one-seventh greater than that of Germany. Ethnically the Bohemians are Slavs. The names Bohemia and Bavaria are both of Roman origin, derived from the name of the Keltic tribe of Boii, the forefathers of the Bavarians who may have extended over, or claimed a part of, Bohemian territory at one time. The name Czech (applied to the Bohemians) is, according to old tradition, derived from that of a leader or chief of the people.

Archaeological excavations have shown that the Slavs were in Bohemia long before the beginning of the Christian era. The earliest historical mention of them occurs in the second and third centuries. They were never subject to Rome, and the Germans were their eternal enemies. At the beginning of the seventh century they were a strong political unit and in 630 were powerful enough to severely defeat the Germans. Thus began historically the marvelous life-and-death struggle of the Czech people with the voracious German flood that would engulf them, a struggle of thirteen centuries, which has lasted until the present day.

The rich Bohemian literature and archives were repeatedly destroyed by the enemy, but enough has been saved to show that those early times were both idyllic and magnificently barbaric. The people were agriculturists and soldiers. Their organization was patriarchal, their government constitutional, almost republican. The religion of Bohemia was naturalistic and poetic. The priests worshiped under great oaks. There was a supreme deity, beside which there are series of bělobozi, or good gods, černobozi and dăsi or demons, vĺly (fairies), vodníci (water-spirits), etc. The burials were by cremation.

From the eighth to the fourteenth centuries the Bohemians were ruled by kings of a strong native dynasty. In 1526 the last of the Bohemian kings perished in a battle with the Turks, and soon afterward Bohemia as well as Hungary joined Austria for mutual protection against the common peril. This was the beginning of Bohemia's misfortunes. During the Thirty Years War the life of Bohemia was nearly extinguished; not until the nineteenth century came the time of a revival and restitution. Today the nation stands at the head of all those comprised in the medieval conglomerate of Austria-Hungary in education, industry, and practically every other respect. It is still shackled and persecuted by Austria but hopes and works for an early victory of the Allied arms and with this its liberation. In 1918 Bohemia will have with the Allies two small armies of its own, one in France and one in Russia.

The 514th meeting of the society was held in the National Museum, October 16, 1917 at 4.30 p.m.

Dr. Mitchell Carroll, Secretary of the Archæological Institute of America, delivered a lecture on *The story of Greece*. The lecture was richly illustrated with lantern slides portraying the principal centers of Greek life, such as Olympia, Delphi, Sparta, and Athens, with the

monuments of architecture and sculpture that have been most influential in the development of art.

Dr. Carroll, in introducing his subject, noted our indebtedness to Greece as five-fold, comprising (1) democracy, (2) obedience to reason, (3) love of beauty, (4) letters, and (5) art. The history of Greece was outlined in seven divisions: (1) The Prehistoric and Heroic Ages to the Dorian migration, 2000–1000 B.C.; (2) the Greek Middle Ages, 1000–500 B.C.; (3) from the Persian Wars to Alexander the Great, 500–386 B.C.; (4) from Alexander the Great to the Roman conquest, 336–146 B.C.; (5) the Roman, Byzantine, and Latin supremacies, 146 B.C.–1453 A.D.; (6) the Ottoman supremacy, 1453–1832; (7) the modern Greek kingdom, 1832.

The racial life of Greece was emphasized by Dr. Carroll, who said "The central fact of all Greek history, from prehistoric times to the present, is the unbroken life of the Greek race. This racial unity rests on common blood, common language, and common institutions."

1. *Race.* From 650 to 850 the Slavs in Greece outnumbered the Greeks, but the Greeks, being superior in civilization, gradually absorbed them. The process of Hellenizing the Slavonians went on steadily until in about 200 years it was practically complete. Thus, between 850 and 1050 was formed the basis of the modern Greek nation. It contains a large infusion of Slavonic blood, but the strain of Hellenic blood has been perpetual and this has determined the type of the modern nationality.

2. *Language.* Greek, though for many centuries crude and ungrammatical, never lost its vitality. In organic matters of structure and syntax Greek has never made a compromise with any foreign language. Briefly, its story has been this. About 300 A.D. the spoken Greek language began to diverge from the literary language, but until 750 Old Greek was generally understood by the people. Then came the breach of Greek tradition, due to the Slavs, and by 900 A. D. classical Greek had probably ceased to be generally understood. Between 1100 and 1200 popular Greek began to have a literature of its own, the popular Greek of the thirteenth century differing little from the popular Greek of today. The chief difference between Old and Modern Greek is that one is synthetic and the other analytic.

3. *Character.* National characteristics of ancient and modern Greeks are: (1) aptitude for city life; (2) ability in commerce; (3) love of mental culture; (4) cleverness. The real core of the Greek nation throughout its history is the agricultural population of Greece proper. The Greek nationality, like the Jewish, has never been crushed out nor lost.

The 515th meeting of the Society was held at the National Museum, November 6, 1917, at 4.30 p.m.

Prof. JAMES H. GORE presented a paper on *Belgium and the Belgians*, illustrated by lantern slides.

Starting with the revolution which resulted in the withdrawal of the part of Holland that afterward became an independent kingdom

with the name Belgium, the speaker explained the duality of languages in Belgium and the ethnic differences between the users of the two tongues.

Immediately prior to the present European war one-tenth of the entire population of Belgium were housed in dwellings which, on easy terms, had become or were becoming the property of the occupants. Thirty-five per cent of the people had accounts in the savings banks and 49 per cent of the inhabitants, male and female, worked at regular callings. Statistics were given to show the thrift of the people, the fertility of the soil, the extent of their foreign trade, and the variety and magnitude of their industries. On each square mile there were 598 inhabitants, and for each inhabitant the railroads annually carried merchandise having a value of $145 as compared with Germany's per capita of $60, and $30 for the United States.

Considerable attention was given to the agricultural commissions —a sort of university extension—which brings to the farmers of the country speakers who tell of recent discoveries and improvements in agriculture that would be of value to the people of each community. To this wise provision can be ascribed a large part of the productivity of Belgium.

The profit-sharing dock laborers of Antwerp were described. It was shown that the prosperity of that port was due to the efficiency of its charging and discharging instrumentalities.

The unique town of Gheel was fully described. In Gheel practically every family cares for one or two feeble-minded persons under the supervision of Government officials. If the family is unable to meet the expense of this care it is borne by the state.

The 516th meeting of the Society was held at the National Museum on Tuesday, November 20, 1917, at 4.30 p.m.

Mr. GEORGE JULIAN ZOLNAY addressed the Society on *Roumania and her people*, illustrating his subject by native music and by lantern slides.

Mr. Zolnay stated that, with the exception of the Roumanian Jews, there are few natives of Roumania in the United States at the present time, and of these a large majority are from Transylvania and the Bukovina. This accounts for the dearth of accurate knowledge concerning this picturesque country, wedged in between the Carpathian mountains and the Black Sea.

The history of Roumania began in 106 when Trajan conquered Dacia, a country comprising the territory now known as Roumania. At the fall of the Roman Empire in the fifth century the descendants of the Roman soldiers and the Dacian women had become a distinct nationality, speaking a slightly modified Latin which has remained the language of the Roumanian people to the present day. The established religion has remained that of the orthodox Greek Church, although Roumania was a vassal state of Turkey for more than 300 years. During the Russo-Turkish war Roumania regained her inde-

pendence and was proclaimed a kingdom in 1881, later taking her place as a leading country among the Balkan States.

One of the most remarkable traits of the Roumanian is his love of his national music. This music is so distinct from that of all other nations that only the native musician can render it with the mysterious quality that stirs the Roumanian soul.

Although the misfortunes of war have temporarily prostrated Roumania, it is to be hoped, in the light of her past history, that she will emerge intact, to prepetuate her Latin civilization in the midst of her alien neighbors.

FRANCES DENSMORE, *Secretary.*

BIOLOGICAL SOCIETY OF WASHINGTON

The 572d regular meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, October 20, 1917; called to order by President HAY at 8.15; 42 persons present.

Informal brief notes were presented as follows:

Gen. T. E. WILCOX: *Occurrence of California vulture in Idaho.* He said: I have been requested to record, as it has been doubted, the occurrence of the California vulture in Idaho, then a territory. In the fall of 1879 I came upon two which were feeding on the carcass of a sheep. They hissed at me and ran along the ground for some distance before they were able to rise in flight. They were much larger than turkey buzzards, with which I was quite familiar, and I was very close to them so that I could not be mistaken in their identity. The cattle-men said that the California vulture or buzzard was not uncommon there before they began to poison carcasses to kill wolves. Dr. Coues gives as their habitat "Rocky Mts. to the Pacific." Boise River mountains rise to over 7000 feet just back of where the vultures were feeding. The exact locality was near the Hot Springs above Boise City. Poison and population have now destroyed that far northern habitat. The *Boise Statesman*, if any of Editor Kelly's time are now living, may be able to confirm the above statement.

Dr. R.W. SHUFELDT exhibited a small living specimen of the southern tortoise, or "gopher," *Testudo polyphemus*, and made remarks on its habits.

Dr. L. O. HOWARD, referring to the previous note, called attention to the peculiar insect fauna found in the burrows of the "gopher," many of the species having the characteristics of cavern dwelling insects.

President W. P. HAY in the same connection remarked on the fact that a species of frog of the genus *Rana* so far as is known is only found in the burrows of the "gopher."

Dr. T. S. PALMER remarked on bird roosts that had lately been observed in the vicinity of Washington, calling particular attention to the martins and starlings in them.

Mr. W. L. McAtee exhibited six rare bird papers which he wished to dispose of for the benefit of the Society.

Mr. William Palmer made comments on some of the papers referred to by Mr. McAtee.

Lieutenant Lyon remarked that among the comparatively small number of stools of patients that he had examined at the Walter Reed General Hospital he had found seven containing ova of *Necator americanus*.

The regular program consisted of three communications:

Dr. T. S. Palmer: *A key to ornithological literature*. This review of the literature of birds was discussed by Dr. L. O. Howard and by Dr. Frank M. Chapman, who mentioned particularly the literature and the active workers on South American birds.

Mr. A. S. Hitchcock: *The alpine flora of the Adirondacks and the White Mountains*. During August Mr. Hitchcock visited the Adirondack Mountains in New York and the White Mountains in New Hampshire for the purpose of studying the alpine grasses. In the former region collections were made on Mt. McIntyre and on Whiteface Mountain, both of which support an alpine flora at the summit above tree line. Mt. Marcy, the highest peak of the Adirondacks (5344 feet), was not investigated because it was impracticable to make the trip in one day from any of the surrounding bases. However Mt. McIntyre (5112 feet), being nearly as high, presents the same conditions as those to be found on Mt. Marcy. Four days were spent among the high peaks of the White Mountains. Entering from the east by way of Crystal Cascade, the speaker ascended through Tuckerman Ravine to the summit of Mt. Washington, passing the night at the Lake of the Clouds Hut (Appalachian Mountain Club). The second day's trip was to the A. M. C. Madison Huts, passing the peaks of Clay, Jefferson, and Adams. The third night was spent at Lake of the Clouds Hut, but the return trail was to the east through the Great Gulf. On the fourth day the descent was made through Huntington Ravine over a difficult trail. Nine species of grasses may be classed as alpine, though a few others extend into the alpine zone from the lower zones (e.g., *Deschampsia flexuosa*, *Calamgrostis canadensis*). The alpine species are *Torresia* (*Hierochloa*) *alpina*, *Phleum alpinum*, *Agrostis borealis*, *Calamagrostis langsdorfii*, *Trisetum spicatum*, *Deschampsia atropurpurea*, *Poa laxa*, *P. glauca*, *Agropyron violaceum*. Most of these are circumpolar species which extend southward in the mountains. The distribution of each species was discussed.

Dr. R. W. Shufeldt: *Notes on some United States batrachians*. Dr. Shufeldt gave life histories and the peculiar habits of a large number of North American forms of this interesting group, all the facts presented having been obtained through personal observations, either upon captive specimens or on the animals in their native habitats in the field. Among the forms touched upon were Jefferson's Ambystoma, which the speaker has reared in captivity, and which he illustrated with lantern slides, showing the eggs in the process of hatching,

as well as the young when several months old. Other forms taken from life and thrown upon the screen were examples of the marbled salamander) *Ambyst omaopacum*) and the elegant spotted salamander (*A. punctatum*), shown in its terrestrial attitudes as well as seen under water. This form is comparatively rare in the vicinity of Washington, less than ten specimens having been collected within the last thirty years. Some six or eight other species of American salamanders were thrown upon the screen to illustrate their forms and attitudes in life.

The peculiar habit the male of the water newt (*Diemyctylus viridescens*) has of hugging the female was shown from living specimens in an aquarium maintained by the speaker at the time these studies were made. This habit of *Diemyctylus* is quite independent of any sexual act during the breeding season, and has been especially referred to in the published life histories of the animal.

Large colored drawings were exhibited, giving the rare Anderson's tree toad and several of the *Hylidae*. Additional presentations by means of lantern were given of all the frogs, toads, and hylas of the Atlantic States, as well as some southern species. The remarkable gopher frog of Florida was fully illustrated and its life history given in considerable detail.

Dr. Shufeldt's remarks were discussed by Messrs. W. P. HAY, WILLIAM PALMER, L. O. HOWARD, A. WETMORE, and A. A. DOOLITTLE.

The 573d regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, November 3, 1917; called to order by President HAY at 8 p.m.; 58 persons in attendance.

Informal brief notes were presented as follows:

Dr. T. S. PALMER called attention to the fact that the first botanical society in this vicinity had been founded one hundred years ago, and that members who failed to attend its meetings were subject to fines. He also exhibited a recently issued Bibliography of British Ornithology, which in addition to the usual bibliographic data contains biographical sketches of the authors of titles listed in the bibliography.

Dr. L. O. HOWARD called attention to the recent centennial celebration of the Medical Society of the District of Columbia.

Dr. H. M. SMITH reported that the recent fur-seal census shows an increase of about 10 per cent over the previous census, the total number being 468,000. He also reported that the flesh of whales, owing to the decreasing supplies of other meats, is being used for human food in the United States, especially on the Pacific Coast.

Mr. C. BIRDSEYE remarked that large quantities of palatable seal meat are annually thrown away by sealers along the northeast coast of North America.

Lieutenant M. W. LYON, JR., exhibited a photograph of a human anatomical anomaly in which a kidney and its corresponding ovary and uterine tube were lacking. It was the third case of congenital absence of a kidney which he had encountered in two years.

Mr. WILLIAM PALMER exhibited a sectioned tympanic bone of a whale and called attention to its great density and hardness.

The regular program consisted of three communications.

Rear-Admiral G. W. BAIRD: *An unusual human specimen.* He commented on and exhibited a lantern slide of a double monster in a native Filipino girl of usual intelligence. The external visible parasite consisted of two lower extremities. She had slight control over these extremities, much less now than when she was a small child.

This communication was discussed by Drs. C. W. STILES, M. W. LYON, JR., and R. W. SHUFELDT.

VERNON BAILEY: *How the pine squirrels help to feed the bears of the Yellowstone Park.* A general account of the bears in the park was given and it was shown that part of their diet consists of pine seeds obtained from cones cut off by squirrels. Cones from which the bears had extracted seeds were exhibited.

C. BIRDSEYE: *The fur industry of Labrador.* A detailed account of this industry, including fur farming, was given and choice skins of the more important fur-bearing animals exhibited. This communication was discussed by Mr. A. WETMORE and Dr. L. O. HOWARD.

M. W. LYON, JR., *Recording Secretary.*

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